DESIGN OF A NOVEL BIONIC RODENT BONE CRUSHER AND ITS APPLICATION

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Abstract –A set of bionic equipment for breaking edible bones from livestock and poultry was designed. The main units of this bone crusher include two crushing stages, the gap adjusting device, bone inlet, and the broken bones exit etc. Each crushing stage consists of two rollers. The rollers in the first and second crushing stage have 20-30 thicker blades and 30-40 thinner and smaller blades around the axle, respectively, The crushing blades is strong and sharp, which imitates the working principle of rodent teeth. The distance of the two crushing roller is adjustable according to the size of bone. When working, raw bones are sent to the crusher through the fixed hopper and broken by the first stage crushing blade. The primary crushed bones fall into the second stage crushing stage underneath and further crushed to smaller size as needed. Compared with the traditional bone crusher that works with knife, saw or spinning blade, this invention can operate continuously and flexible to different size and shape of bone, thus increase the production efficiency and economic benefits of byproduct utilization greatly.

Key Words –Bone, Crusher, Bionic design.

I. INTRODUCTION

China is one of the countries with largest number of livestock and poultry in the world, which produces about 12 million tons of animal bone each year, accounting for 30% of the total amount of the world [1]. Bone contains about19% protein, an thus about 2 million tons of protein can be extracted from those bones [2]. However, most of the bones were processed into fodder or thrown away directly, which is a waste of valuable nutrients and causes environmental pollution. For livestock and poultry bone processing, the broken processing is critical to improve the utilization efficiency because the size and homogeneity of broken bones have great impact on the extraction efficiency of the following process and final recovery ratio. Currently, most of the bone crushers are directly copied from the crusher in the non-food industry [3]. It is hard for traditional crushers to break these different size and shape of bones into unified size completely, for the raw bones are different in shape, size and hardness from different animal species including cattle, pig, sheep or even fish. Therefore, it is very common to repeat the crushing process due to the unqualified and uneven size of the broken bone pieces after the one round crushing by the current equipment [4].

In this study, a new bionic crushing machine was invented by imitating the working principle of rodent teeth, aiming to develop an easy to operate, cost-saving, energy-saving, high efficiency with low maintenance cost equipment for pretreatment of animal bone. It was designed to be used to process variety kinds of raw bones into unified size and shape, comparing with the traditional crushing machines.

II. MATERIALS AND METHODS

Material

This novel bone broken machine was designed to adapt kinds of animal bones. Therefore a wide-range of raw material can be broken especially swine and cattle. Including pig ham bones, cow leg bones, cow spinal bones and so on. Raw bones whose diameter range from approximately 3cm to 20cm could be crushed through this equipment.

Equipment Composition

This equipment consists of the adjusting system (the first adjustment hand wheel, the second adjustment hand wheel, guide hole, ball screw nut etc.), the crushing system (the first crushing stage, the first stage fixed crushing roll, the second stage mobile crushing roller, the second stage fixed

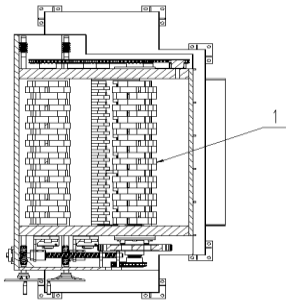
crushing roll etc.), the transmission system (the sprocket department, the sprocket wheel, the chain, gears, the idler, broken bones slide, the worm, worm gear etc.), the motor, the raw bones inlet and the broken bones exit. The crushing system is the main unit of this design, and it will be given more detailed information in this paper.

Crushing system

The first stage

The first crushing stage contains the first stage mobile crushing roller, the first stage fixed crushing roller, the wide crushing blades (on the roller), the first adjusting ball screw, the first transmission chain wheel, the bearings and the gears. The first stage mobile crushing roller, also called the first driving roller which is consisted of rotating axel and crushing blade, is located in the rack and supported by the bearing. At one end of the first stage mobile crushing roller, there is a driving wheel and connected with the coupling device [5]. There are 20-30 wide crushing blades on the mobile crushing roller in certain interval in between. The quantity of breaking blade on both roller can be adjusted according with the demand of producing. The first stage fixed crushing roller, also called the first driven roller, is located in the rack near the mobile crushing roller and supported by the bearing. At one end of the first stage fixed crushing roller, there is a driven wheel which engaging with the driving wheel. Under the rotation of the first driving roller, the two crushing roller with the wide teeth blade rotate in the reverse direction, squeezing and biting the big edible bone into middle pieces (5~10 cm). If the bones are extremely large, in order to prevent the broken blades slippage, the distance between two rollers in the first crushing stage can be increased to achieve the effective broken bite.

Figure 1. The first crushing system

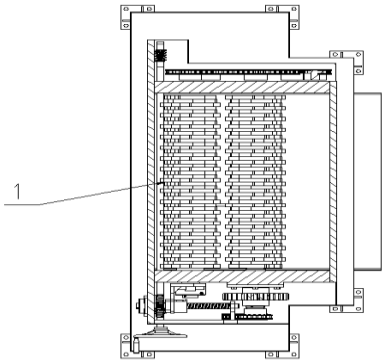


1. The primary crushing rollers

The second stage

The second stage locates just below the first stage. The second stage mobile crushing roller, also called the second driving roller, is located in the rack and supported by the bearing, is consisted of rotating axel and crushing blade. At one end of the second stage mobile crushing roller, there is a driving wheel and connected with the coupling device. There are 30-40 narrow crushing blades on the mobile crushing roller in certain interval in between which are thinner and smaller. The second stage fixed crushing roller, also called the second driven roller, is located in the rack near the mobile crushing roller and supported by the bearing. At one end of the second stage fixed crushing roller, there is a driven wheel which engaging with the driving wheel. There are also 30-40 narrow crushing blades on the fixed crushing roller in certain interval in between. The blades from the mobile roller and the fixed roller sequentially interlace. Under the rotation of the second driving roller, the two crushing roller with the narrow teeth blade rotate in the reverse direction, squeezing and biting the big edible bone into middle pieces (3~5 cm). Just the same as the first stage, the distance between two crushing roller can be changed according to the situation of producing. What's more, the amount of blades on the crushing roller has great influence on efficiency. Thus, the amount of blades on both first and second stage rollers can be increased to enhance bone-crushing efficiency.

Figure 2. The second crushing system



1. The senior crushing rollers

III. RESULTS AND DISCUSSION

Here is an example on how to use the invented two-stage bone crusher. The thawed raw edible bones or skeletons are sent to the raw bone inlet by the conveyor belt. Those big pieces of bone fall into the first crushing stage. Under the rotation of driving shaft, the two crushing roller with the wide teeth blade rotate in the reverse direction, squeezing and biting the large edible bone into middle size pieces (5~10 cm). Then, the primary crushed bones were sent to the second crushing stage. The teeth width of the second stage blades is smaller than that of the first stage. After second stage crushing, the primary crushed bones are further crushed into small qualified pieces (3~5cm), and passed through the broken bones exit, fall on the conveying belt and transported to next process. Comparing with the traditional crusher, there are several advantages of the invented bionic rodent bone crusher:

Firstly, the new crusher contains a uni-directional active steel plate at raw bones inlet, which prevent the broken bone slags from splashing. The double crushing stages has combined 2 set of traditional bone crusher together into a vertical structure and made this space-save new equipment, with high efficiency to break bones with different size and various shapes.

Secondly, this crusher make turbines at two ends of breaker roll rotate by adjusting distance changing hand wheel. This kind of adjustment could avoid the cylinder being too heavy which may lead cylinder to being uneven and jammed inside.

Last but not least, the crusher adopts belt transmission to solve the previous problem of the traditional crusher, which is due to the direct transmission. The jam of bone pieces in the machine may damage the machine. The solution is that the motor deceleration device is installed to the lower part of the crusher to increase the stability of the entire device and make the machine run more smoothly.

Table 1 comparison of traditional and novel bone crusher

Item	Traditional crusher	Novel rodent crusher
Crushing speed	Slow	Fast
Manner of breaking	Repeat	One-time
Transportation	Belt	Gravity falling
Jam accident	Yes	No
Product quality	Unevenness	Uniform
Breaking rate	98%~99%	100%
Efficiency	Low	High
Size of raw material	Suitable size	All size
Energy consumption	High	Low
Floor space	Big	Small
Maintenance cost	High	Low
Complexity	Complex	Convenient
Economical benefits	Limited	Great

IV. CONCLUSION

A kind of equipment for breaking bones from livestock and poultry named as bionic rodent bone crusher was developed in this study. This new equipment simplified the breaking process of animal bones and made the pretreatment of whole bone into a continuous process instead of the traditional batch processing， thus made bone crush a much easier process during utilization of animal bone. The new equipment is expected to save space and bring larger profits to enterprises related to utilization of animal bones.

ACKNOWLEDGEMENTS

The research of meat-bone equipment is assisted by National agricultural science and technology innovation project.

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